Coll. Antropol. **43** (2019) 1: 21–30
Original scientific paper

Morphological Characteristics of Portuguese Rhythmic Gymnasts in Different Competition Levels

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ABSTRACT

This study aimed to: (1) compare morphological and training characteristics in Portuguese gymnasts across competitive levels; (2) investigate the morphological variables with higher discriminatory power between groups; (3) determine which morphological variables better explain performance. The sample (n=164) consisted of gymnasts at three competition levels (base, 1st division and elite) from Portugal. 19 anthropometric and 2 body composition measurements were performed. Somatotype was defined by Health-Carter method. Training data were collected by interviewing. For the statistical analyses, Kruskal-Wallis test, linear regression and discriminant function were used. Portuguese gymnasts (13.5±2.0 years) presented 43.7±9.3 kg of body mass, 152.6±8.9cm of height, 18.5±2.4k g/m² of BMI, 17.5±4.1% of body fat, endomorph-ectomorph somatotype and 16.9±7.5 hours/week of training volume. Elite gymnasts differed from other groups in having lower skinfolds and body fat; and higher training volume and training years. The elite and the 1st division showed higher ectomorphy and lower endomorphy component than the base. Thus, the elite presented morphological and training characteristics closer to the international standards, followed by the 1st division and the base. The variables that best discriminate the gymnasts by competition levels were body fat and lower limb length. Furthermore, body fat was the main morphological predictor of performance in competition

Key words: *anthropometry; body composition; somatotype; rhythmic gymnastics; Portuguese gymnasts.*

Introduction

Over the last decades, many studies have been performed in order to define what could be the ideal body shape for different sports[3]. In Rhythmic Gymnastics (RG) is known that the body dimensions and anthropometric characteristics, among others factors, have a high impact on performance[12,14,30], once they affect the evaluation of the judges, although the RG Code of Points does not include penalties for the morphological profile of gymnasts[3,4]. Furthermore, in a sport of great aesthetics such as RG, the perception of body image becomes a fundamental factor of the psychological well-being of gymnasts[38].

Morphological characteristics of rhythmic gymnasts are determined by different factors, such as genetic aspects, training level, specific nutritional plans[37] and maturity status[28], which favor the optimum physical condition for the sport[16]. Thus, the particular biotype and body pattern of the rhythmic gymnasts seem to be important requirements for an efficient performance of the specific movements in this modality[1,29,31]. Šebić-Zuhrić, et al.[34] and Douda, et al.[16] suggest that the morphological characteristics have a high predictive value in RG performance.

The knowledge about the morphological characteristics of gymnasts of different competition levels can contribute to the identification of the degree of importance of each of these characteristics in the performance[21] and becomes relevant to selection processes[2].

Taking into account the fact that there are no relevant data on the morphological characteristics of Portuguese RG in the literature, the purpose of the present study were: (1) compare morphological (anthropometrics measurements, body composition and somatotype) and training characteristics in Portuguese gymnasts across competitive levels; (2) investigate the morphological variables with higher discriminatory power between groups and (3) verify the morphological variables the better explain performance.

Received for publication November 11, 2018

Materials and Methods

Subjects

164 Portuguese gymnasts who participated in the district and/or national competitions in the sport season 2013/2014, in three different competition levels: base, 1st division and elite.

Ethical Considerations

The study protocol was approved by the Ethics Committee of the Faculty of Sport, University of Porto (Portugal) and the Scientific Committee of the Portugal Gymnastics Federation, after of recognized its scientific value and multiple benefits. The assessments were performed in accordance with the ethical standards of the Helsinki Declaration.

Anthropometrics Measurements and Body Composition

Anthropometric measurements were obtained according to the protocol established in Anthropometric standardization reference manual[27]. All anthropometric measurements were performed at the beginning of each training session by the same trained anthropometrist assisted by recorders who were familiar with the specific procedures. Body mass (kg) was measured with a portable bio-impedance scale (Tanita BC-558 Ironman Segmental Body Composition Analyzer) with a 0.1 kg precision. Height (cm) and sitting height (cm) were determined to the nearest 0.1 cm using the portable stadiometer Personal Sanny, with the head positioned in the Frankfurt plane. Upper limb length was measured with a Segmometer (Rosscraft). The lower limb length was estimated based on the difference between standing height and sitting height. All diameters (biacromial, bicristal, humerus and femur) were measured to the nearest 0.1 cm with a SH-108 compass round tip. Relaxed and flexed arm, thigh and calf girths were assessed, using an anthropometric measuring tape Sanny, to the nearest 0.1 cm. Triceps, subscapular, suprailiac, abdominal, thigh and calf skinfolds were measured with a Holtain Skinfold Caliper (0.2 mm precision). The measurements were performed in duplicate or when necessary in triplicate. The low values of technical error of measurement verified during the quality control of the information determined a high precision and reliability of the data. Relative body fat (%BF) was calculated using the equation proposed by Slaughter, et al.[35]: [(0.610 * ΣSKF) + 5.1], where, ΣSKF is the sum of triceps and calf skinfolds. Body mass index (BMI) was calculated from the equation: body mass (kg) / height^2 (m).

Somatotype

The somatotype and calculation of its components were performed according to the Health-Carter method [8].

Additional data

Chronological age, age of training onset, and training volume were collected using questionnaries (Table 1). Scores in the Portuguese National Championship determined the competitive performance in the sport season 2013/2014.

Statistical Procedures

Statistical analysis we used was performed using the Statistical Package for Social Sciences (SPSS 23.0) The significance level was set at 5%. Descriptive statistics were performed using the mean and standard deviation. Kruskal-Wallis test was used to compare competition levels in different analysis. For the construction of morphological profile, the variables were transformed into score Z. Somatotype calculations and their graphical displays in the somatocharts were done in the MER Goulding Software Development. We used also the Discriminant function to verify the variables that maximally separate the groups of gymnasts by competition levels, and the pearson corelation and linear regression to determine which of the morphological variables better explain the performance.

Results

Table 1 shows the training and morphological characteristics of Portuguese gymnasts divided by competition levels.

We verified that the higher the competition level, the higher was the training volume per week and years of practice in RG. In the training onset (age at which each child started RG training) significant differences between the groups were not observed, despite the fact that the higher the competition level, the lower was the training onset.

Nowere found in variables significant differences in body mass, height, upper and lower limbs length in the competition levels. However, although without statistical significance, the elite gymnasts were taller, showed higher upper and lower limb length than the other gymnasts.

In other anthropometric variables, we can see significant differences in all groups only in skinfold measurements. The higher the competition level, the lower were the skinfolds values. Furthermore, although without statistical significance, the higher the competition level, the lower were the girth measures, except for calf girth. In the diameter measures, the groups presented very close values and no structural pattern was observe in the results found.

In the somatotype components, significant differences were found with respect to endomorphy and ectomorphy. Base level gymnasts showed higher values of endomorphy and lower values of ectomorphy than other groups. The competition levels gymnasts had similar values for the mesomorphy component.

TABLE 1.
TRAINING AND MORPHOLOGICAL CHARACTERISTICS FOR COMPLETE SAMPLE AND SEPARATED BY COMPETITION LEVELS

Competition level / Variables		General (N=164)	Base (N=83)	1st division (N=72)	Elite (N=9)	Proof value
		x±sd	x±sd	x±sd	x±sd	
Age (years)		13.5.±2.0	13.3*±1.9	13.6±2.1	14.8*±1.8	p=0.016 [b]
Training onset (years)		6.9±2.4	7.3±2.6	6.5±2.2	6.0±1.5	p=0.082
Years practice (years)		6.2±3.0	5.6*±3.1	6.7*±2.8	8.2*±1.9	p=0.011 [a,b,c]
Training volume (h/week)		16.9±7.5	13.9*±6.4	18.7*±6.2	31.2*±6.2	p≤0.001 [a,b,c]
Body mass (kg)		43.7±9.3	45.1±9.4	42.1±9.5	42.6±6.1	p=0.094
Height (cm)		152.6±8.9	152.7±7.8	152.1±10.3	155.8±6.6	p=0.489
Upper limb length (cm)		67.0±4.8	67.2±4.9	66.6±4.8	67.9±3.6	p=0.638
Lower limb length (cm)		73.8±4.6	73.3±4.0	74.1±5.2	76.3±3.7	p=0.056
Diameters (cm)	Biacromial	33.4±2.6	33.2±2.6	33.4±2.7	34.0±1.9	p=0.803
	Bicrital	22.7±2.3	23.0±2.0	22.5±2.6	22.5±1.6	p=0.292
	Humerus	5.2±0.4	5.3±0.3	5.2±0.4	5.4±0.3	p=0.207
	Femur	7.4±0.6	7.4±0.6	7.3±0.6	7.1±0.4	p=0.079
Girth (cm)	Relaxed arm	22.1±2.7	22.5±2.8	21.8±2.6	21.0±1.3	p=0.058
	Flexed arm	23.9±2.4	24.3±2.4	23.6±2.5	23.2±1.4	p=0.079
	Thigh	44.5±5.1	45.3±5.4	43.8±4.8	42.8±3.0	p=0.067
	Calf	31.4±3.1	31.8±3.3	31.0±3.0	31.2±2.1	p=0.181
Skinfolds (mm)	Triceps	10.4±3.5	11.8*±3.7	9.2*±2.5	6.7*±1.3	p<0.001 [a,b,c]
	Subscapular	7.4±2.8	8.5*±3.2	6.6*±1.9	5.1*±0.5	p<0.001 [a,b,c]
	Suprailiac	10.8±4.9	12.5*±5.3	9.1*±3.7	7.7*±1.6	p<0.001 [a,b,c]
	Abdominal	9.4±4.2	11.0*±4.5	7.9*±3.1	6.0*±1.3	p<0.001 [a,b,c]
	Thigh	15.8±4.5	17.3*±4.7	14.6*±3.8	12.4*±2.2	p<0.001 [a,b,c]
	Calf	10.0±3.6	11.6*±3.2	8.7*±2.8	6.1*±1.3	p<0.001 [a,b,c]
Somatotype	Endomorphy	3.2±1.1	3.7±1.1	2.8±0.8	2.1±0.4	p<0.001 [a,b]
	Mesomorphy	2.6±0.8	2.8±0.9	2.5±0.8	2.1±0.6	p=0.059
	Ectomorphy	3.4±1.1	3.0±1.1	3.6±1.0	4.2±0.8	p<0.001 [a,b]
Body mass Index (kg/m^2)		18.5±2.4	19.1*±2.6	17.9*±2.1	17.5*±1.5	p=0.008 [a,b]
Body fat (%)		17.5±4.1	19.4*±4.2	18.2*±4.3	14.6*±2.8	p<0.001 [a,b,c]

* p≤0.05: significant differences – a) base versus 1st division; b) base versus elite; c) 1st division versus elite.

Significant differences were verified also in all body composition variables. The higher the competition level, the lower were the values of %BF and BMI, although significant differences were not observed in BMI between those in the 1st division and elite group.

The morphological profile of Portuguese gymnasts by competition levels (Figure 1) presents clear differences by the groups.

Figure 1 shows that the 1st division and elite gymnasts had similar below average values in body mass. On the other hand, the base level gymnasts presented higher above average values for this variable. In the longitudinal linear measures (height, upper and lower limb length), the elite showed above average values higher than the other groups. In BMI, %BF, skinfolds and girth measures, elite and 1st division gymnasts had values below average, with lower values found in the elite level, except for the calf girth, where the groups showed similar values. The base had values above average in all these measures. We did not identify the structural pattern in the results of diameters measures, with average values, and above and below average values in different groups. In the somatotype components, the groups presented similar values in mesomorphy. The higher the competition level, the lower endomorphy and the higher ectomorphy components were observed. In endomorphy, the elite and the 1st division had values below average and base had values above average. In ectomorphy the opposite was verified.

Portuguese gymnasts (N=164) showed an endomorph-ectomorph somatotype, and the values of their components (endomorphy, mesomorphy and ectomorphy, respectively) were 3.2–2.6–3.4. Figure 2 presents all 164 profiles (quadrilaterals) with the mean somatotype (circle).

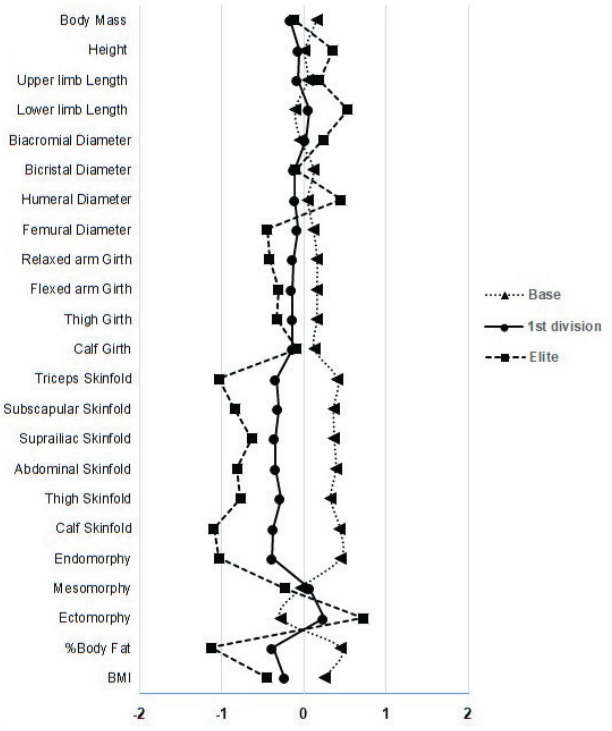

Fig 1. Morphological profile of Portuguese gymnasts by competition levels based in the scores Z. BMI – body mass index.

Somatocharts by competition levels is shown in Figure 3. The groups presented different somatotypes (F=11.91, p<0.001): balanced endomorph (3.7–2.8–3.0) in the base; balanced ectomorph in the 1st division and the elite (2.8–2.5–3.6 and 2.1–2.1–4.2, respectively).

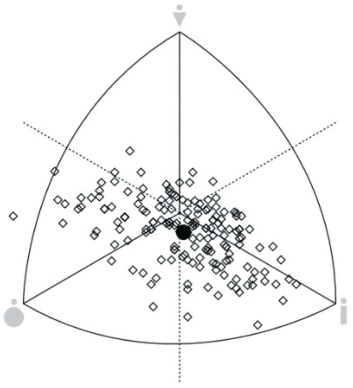

Fig 2. Somatochat of Portuguese gymnasts' body type. – endomorphy; – mesomorphy; – ectomorphy; The quadrilaterals are individual somatotypes and the circle is mean profile

According to the discriminant analysis, %BF (ʌ de Wilks = 0.977, F = 24.679, p<0.001) and lower limb length (ʌ de Wilks = 0.765, F = 14.285, p<0.001) were the variables that maximally differentiated the groups of gymnasts by competition levels. The reclassification in the original groups based on the results of the discriminant function showed that 59.8% of gymnasts were correctly classified (Table 2).

We observed that the lower errors of reclassification occurred in the elite level (22.2%). In the base level, 33.7% of gymnasts were reclassified in other competition levels: 30.1% in the 1st division and 3.6% in the elite. The 1st division was the competition level with higher errors of reclassification (50%): 27.8% of gymnasts were reclassified in the elite level and 22.2% in the base level.

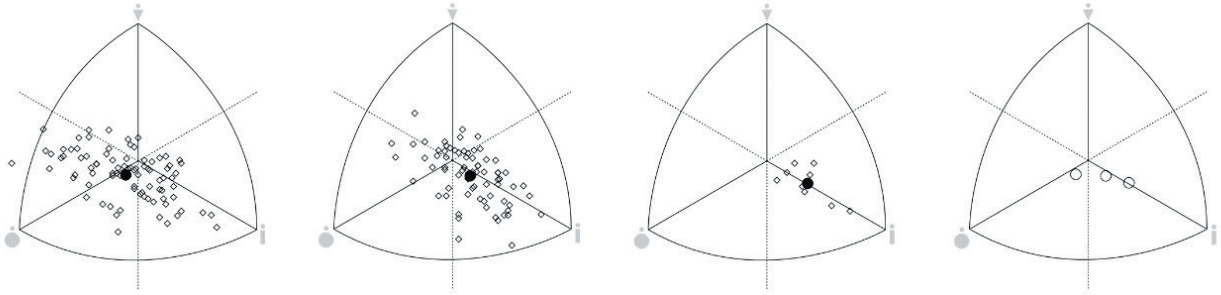

Fig 3. Somatocharts of Portuguese gymnasts' body type by competition levels. – endomorphy; – mesomorphy; – ectomorphy; The quadrilaterals are individual somatotypes and the circle is mean profile.

TABLE 2.

CLASSIFICATION OF GYMNASTS IN THE DIFFERENT COMPETITION LEVELS (BASE, 1ST DIVISION AND ELITE).

		Competition Level	Predicted Group Membership*			Total
			Base	1st division	Elite	
Cross-validated	Count (%)	Base	55 (66.3%)	25 (30.1%)	3 (3.6%)	83 (100%)
		1st division	16 (22.2%)	36 (50.0%)	20 (27.8%)	72 (100%)
		Elite	0 (0%)	2 (22.2%)	7 (77.8%)	9 (100%)

*59.8% of cases grouped with cross-validation correctly classified.

Finally, the linear regression showed that %BF was the morphological variable that better explained the variability of performance in competition ($F=21.993$; $p<0.001$; adjusted $R^2=0.156$). Only this variable exploined 15.6% of the variance of score in the competition. The equation of regression was: Score in competition = 35.109 – 0.419 x %BF; thus, increases in %BF causes a decrease in the score in competition.

Discussion

Information about the training characteristics in RG is essential to understand its effects on the growth and development of gymnasts[7], since the morphological characteristics are among the factors that condition the performance in this sport[12,16,34].

Portuguese gymnasts presented age of training onset in RG (6.8±2.4 years) according to previous studies: 6.8±1.9 years[18], 7.7±2.2 years[20]; 7.4±2.3 years[36]; 6.2±1.9 years[6]; 6.5±1.4 years[4]. However, we also observed in our study that the higher the competition level, the was lower the age of training onset: 7.3±2.6 years in the base group, 6.5±2.2 years in the 1st division and 6.0±1.5 years in the elite, although without statistical significance. The age of training onset in elite gymnasts is in accordance with indications by several authors[19,26,31] who suggest that the RG training begins at an early age of 5–6 years and it continues throughout childhood and adolescence.

Portuguese gymnasts at different competition levels presented different training volume per week. Elite gymnasts had significantly higher training volume than the remaining two groups probably due to high physical and technical requirements in the training and competition, essential to maintain this higher level of sport performance.

According to Ávila-Carvalho, et al.[3], to achieve the necessary preparation for a good performance, elite gymnasts train 25–30 hours/week and in some cases, 40 hours/week. The gymnasts who participated in the European Championship of 1986 had a training volume of 21.7 hours/week and in 2008, 36 hours/week[6]. These data demonstrate a tendency to increase the training volume over the recent years. During the 1970's and 1980's the requirement was 15 and 20 hours/week, respectively[19]. Portuguese elite gymnasts in our study presented higher training volume (31.2±6.2 hours/week) than Portuguese junior elite gymnasts (25.0h±0 hours/week) studied by Batista-Santos, et al.[5].

Several studies have pointed out that low body fat, narrow and thin bodies and hips, long and thin limbs, and an balanced ectomorphic somatotype are important selection and performance criteria, distinguishing elite from non-elite rhythmic gymnasts[4,7,16,23,24,32].

However, it is important to emphasize that the linear body measures (e.g., height, lengths and diameters) tend to have a higher genetic influence than girths, skinfolds, body mass, body fat which can be affected by training as a result of adaptive processes[15]. Thus, the anthropometric variables such as arm span, leg length, and height are identified as determinants of performance, but they cannot be altered by training and mainly depend on the initial and long-term selection processes across ages[25].

According to Ávila-Carvalho, et al.[4], apparently in the past rhythmic gymnasts were younger and thinner than today. The authors believe that the increase in elite gymnast's age means an increase in the longevity career in RG, and this can affect the high level senior gymnasts new body appearance model of high level senior gymnasts[4,6]. However, the visual appeal and body aesthetics remain critical factors in the success in RG. Thus, we verified that the elite gymnasts presented lower values of BMI and %BF than other competition levels, although without statistical significance for BMI in the elite (17.5±1.5 kg/m^2) versus the1st division (17.9±2.1 kg/m^2).

Portuguese gymnasts (13.5±2.0 years) presented body mass of 43.7±9.3 kg. For this variable, no significant differences were found by the competition levels. However, analyzing body mass by competition levels, as expected, the base level had higher values (45.1±9.4 kg). On the other hand, the elite (42.6±6.1 kg) showed slightly higher values than the 1st division (42.1±9.5 kg). We believe that this difference could be attributed to their chronological age, since the elite gymnasts (14.8±1.8 years) were somewhat chronologically older than the 1st division gymnasts (13.6±2.1 years) and the 1st division (42.1±9.5 kg) showed similar body mass.

Compared to more recent investigations in rhythmic gymnasts aged similarly to those in our study, we verified lower values[32] in gymnasts with 13.0±2.8 years and 40.6±11.3 kg and higher values[2] in gymnasts with 13.7±0.8 years and 47.0 kg.

Based on the BMI cut-off points for girls of different ages[9], 85.4% (N=140) of Portuguese gymnasts had normal nutritional status (normal weight). However, we found that 11.6% (N=19) of gymnasts were underweight: 4 gymnasts in the thinness grade 2 (one from base level and three from the 1st division); 15 gymnasts in the thinness grade 1 (four from base level, eight from the 1st division and three from the elite). On the other hand, although it was not expected, 3.0% (N=5) of gymnasts were overweight, all from the base level group.

Georgopoulos, et al.[18] conducted a study with 255 rhythmic gymnasts, aged 14.7±2.1 years, participating in the European Championship in Greece. The gymnasts presented, 16.3±1.8 kg/m^2 of BMI, 16.1±4.1% of %BF and 42.0±7.4 kg of body mass. Theodoropoulou, et al.[36] studied 423 elite rhythmic gymnasts aged 15.9±2.4 years in the period from 1997–2004 on World and European Championships and verified that the values of BMI and %BF were 16.9±1.8 kg/m^2 and 15.5±4.6% respectively. Del Vecchio, et al.[10] observed that Brazilian junior gymnasts had 17.1±1.5 kg/m^2 of BMI. Portuguese gymnasts in our study showed higher values of both BMI (18.5±2.4 kg/m^2) and %BF (17.5±4.1%). When we analysed the values by competition levels, we found that only the elite gymnasts had

values of BMI (17.5±1.5 kg/m^2) and %BF (14.6±2.8%) closer to the studies reported[10,18,36].

Klentrou, et al.[22] provide information about the height orientations for rhythmic gymnasts and the authors presented five height intervals according to the age: improbable (+); optimal; possible and improbable (–) height. The Portuguese gymnasts showed an optimal height with respect to age (13.5±2.0 years and 152.6±8.9 cm of height). However in the analysis by age groups we observed that Portuguese gymnasts (10–11 years) had improbable positive height (144.3±6.4 cm), the gymnasts between 11 to 15 years had an optimal height and the gymnasts between 15 to 18 years presented only possible height with respect to age.

Comparing our complete sample with gymnasts of similar mean age (13.4±1.6 years) studied by Douda, et al.[16], we verified equivalent height values (151.1±9.5 cm). In another study performed by Camargo, et al.[7], the gymnasts of similar mean age (13.4±0.6 years) had 155.9±4.5 cm of height, however, they showed a more advanced pubertal stage (peak height velocity +2) than Portuguese gymnasts (peak height velocity –1).

Elite gymnasts had optimal height[22] and we found that the this group presented higher values of height (155.8±6.6 cm) than the base and the 1st division ones albeit without statistical significance. Further, there was no structural pattern expected in the results found in the height of gymnasts in different competition levels, as elite gymnasts were taller, followed first by the base gymnasts and then by the 1st division gymnasts.

The other anthropometric measurements used in our study, including lengths, girth, diameters and skinfolds are little studied, probably due to temporal and operational difficulties in performing this type of assessment in gymnasts.

The lengths of the upper and lower limbs are differential factors in gymnastics. According to Georgopoulos, et al. [20], the short-limbed gymnast would have a greater mechanical advantage in the performance of artistic gymnastics, while a gymnast with long limbs could benefit from a similar advantage in RG. Thus, rhythmic gymnasts are expected to have long and thin extremities[1,31]. In agreement with that, the elite gymnasts presented higher values of upper and lower limbs length than other competition levels, although without statistical significance. Unexpectedly, in height and upper limb lengths, the base showed higher values than the 1st division.

In the skinfolds measures, the higher the competition level, the significantly lower were the values observed. Furthermore, although without statistical significance, the higher the competition level, the lower were the girth measures, except for calf girth. In the diameter measures, the groups had very close values and there was no the structural pattern in the results found.

Portuguese gymnasts showed lower values of thigh (44.5±5.1 cm) and calf (31.4±3.1 cm) girth, higher values of thigh skinfold (15.8±4.5 mm) and similar values of calf skinfold (10.0±3.6 mm) and femur diameter (7.4±0.6 cm) than the Brazilian gymnasts studied by Frutuoso, et al.[17]: thigh (45.2±3.0 cm) and calf (33.2±2.3 cm) girth, thigh (14.1±5.0 mm) and calf skinfold (10.0±5.0 mm); femur diameter (7.1±0.4 cm). On the other hand, the elite Portuguese gymnasts presented lower values in all these measures, except for femur diameter with similar values.

Di Cagno, et al.[11] performed the same diameter measures as our study with junior and senior gymnasts. The gymnasts had higher values in humerus (5.6±0.4 cm and 6.0±0.4 cm) and femur (8.1.±0.5 cm and 8.4±0.2 cm) diameters and lower bicristal (22.3±2.7 cm and 25.0±1.3 cm) and biacromial (30.8±3.1 cm and 32.1±1.5 cm) diameters than Portuguese gymnasts (except for bicristal diameter in senior gymnasts). Furthermore, the authors also analyzed the sum of three skinfolds (triceps, subscapular and suprailiac) and found the following values: 21.5±5.9 mm in junior and 21.3±2.4 mm in senior. Thus, it seems that the Portuguese gymnasts presented higher values in the sum of skinfolds (28.5±10.2 mm) than the gymnasts studied by Di Cagno, et al.[11]. When compared by different competition levels, only the elite achieved lower values in the sum of skinfolds: the base (32.8±11.1 mm), the 1st division (24.8±7.1 mm) and the elite (19.5±2.9 mm).

Kritikou, et al.[24] showed that the deductions of artistry score in the RG competition presented positive significant correlations with subscapular and suprailiac skinfolds and negative significant correlations with lean body mass. According to the authors, these data indicate that a lean body shape may be indirectly encouraged by the RG Code of Points, as previously suggested by Ávila-Carvalho, et al.[4].

Several authors have proposed that the most common somatotype profile in RG is the balanced ectomorph, which implies a dominance of the ectomorphic component, with similar prevalence and moderate values in the remaining components[1,7,24,31–33]. However, there are studies that found different somatotypes in rhythmic gymnasts such as the mesomorph-ectomorph[2,38], as well as the central somatotype[2,38], mesomorphic ectomorph[1] and even the balanced endomorph[33].

In the Portuguese sample the average somatotype was 3.2–2.6–3.4, classified as endomorph-ectomorph, with a low mesomorphy component and similar prevalence in the endomorphy and ectomorphy components. Qualitatively, it can be seen as exhibiting a moderate relative fatness and subcutaneous body fat; moderate relative linearity and less volume per unit of height; and a low muscle-skeletal development, with narrow skeletal and muscle diameters[8].

As previously reported, the gymnasts at different competition levels had similar body mass, height, diameters and girths. However, the higher the competition level, the lower were the %BF and skinfolds measures. We verified also that the higher the competition level, the higher was the training volume. Thus, the 1st division and the elite (2.8–2.5–3.6 and 2.1–2.1–4.2, respectively) were according to the expected somatotype profile in RG:

balanced ectomorph, thus confirming previous evidence on the importance of ectomorphy as a selection criterion in RG[32,38]. On the other hand, the base presented the balanced endomorph (3.7–2.8–3.0) somatotype, which implies a dominance of the endomorphy component, with similar prevalence and moderate values for the mesomorphy and ectomorphy components. The main characteristics of balanced endomorph gymnasts are moderate relative fatness and subcutaneous body fat; low muscle-skeletal development and relative linearity[8]. In accordance with that, the base level gymnasts showed a significantly higher endomorphy component and a lower ectomorphy component than the other competition levels.

Although this body pattern is not expected in RG, Quintero, et al.[33] observed also a balanced endomorph somatotype in rhythmic gymnasts (15–18 years). However, this sample did not include the elite gymnasts.

Menezes, et al.[29] studied the somatotype of Brazilian gymnasts at three different competition levels and showed that higher competition levels presented the balanced ectomorph somatotype (National level 2.7–2.7–4.2 and International level 2.3–2.9–4.2), while gymnasts at the Regional level had an ectomorphic mesomorph somatotype (2.9–3.2–3.5).

The elite Portuguese gymnasts, who represent the highest competition level in our study, are a selected group of girls exposed to RG training since early childhood, and they demonstrated unique characteristics: low %BF, optimal height to their age, a balanced ectomorph somatotype, high training volume and high number of years of practice in the sport. Furthermore, this group showed long extremities, low values of skinfolds and girths measures.

However, the low %BF seem to be one of main parameters to reach high results in RG[11,24]. In a study performed by Donti, et al.[13], the %BF was the main morphological characteristic that differentiated qualified and non-qualifiers rhythmic gymnasts in the all-around competition. Furthermore, morphological variables such as body composition have been suggested as significant determinants of the RG competition score[16,32].

Thus, in the regression analysis, we verified that the %BF was the main morphological predictor of performance in competition and this variable explained alone 15.6% of competition success. On the other hand, we performed also the discriminant analysis to find the morphological variables that better discriminate the three competition levels. The results showed that the %BF and the lower limb length were the variables that maximally separated the groups. We observed that 40.2% of gymnasts presented errors of reclassification in the original groups, i.e. these gymnasts had characteristics less similar to their group of origin and more similar to another group. The lower errors of reclassification occurred in the elite level (22.2%). These gymnasts were reclassified to the 1st division. In the base level, 33.7% of gymnasts were reclassified in other competition levels: 30.1% in the 1st division and 3.6% in the elite. The 1st division was the competition level with higher errors of reclassification (50%): 27.8% of gymnasts were reclassified in the elite level and 22.2% in the base level. Thus, we showed that some gymnasts of the base and the 1st division were closer in morphological characteristics to the elite. This analysis shows a high inter-individual variability in these groups. However, there are several other contributing factors to performance in RG, thus only the morphological characteristics cannot determine the gymnasts' membership at a certain competition level. Furthermore, in Portugal, the gymnasts compete in the base or 1st division levels depending on the subjective preferences and decisions of the coaches. On the other hand, the elite level is composed of gymnasts selected by the Portugal Gymnastics Federation according to the scores previously attained in specific competitions of the junior and senior categories. These gymnasts form the individual Portugal National RG Team. Therefore, the elite gymnasts have several special characteristics, which allow them to be in this selected group.

Conclusions

According to the analysis by the three competition levels of performance, the elite Portuguese gymnasts significantly differed from the base and the 1st division ones in having lower skinfolds and %BF, higher training volume per week and a number of years of practice in RG. The elite and the 1st division showed a significantly higher ectomorphy component and a lower endomorphy component than the base. In addition, although without statistical significance, some data are still substantially relevant: in body mass, the elite and the 1st division presented similar values and lower than the base. In the longitudinal linear measures (height, upper and lower limb length), the elite had higher values than other groups. Contrary to what is expected, in height and upper limb length, the base showed higher values than the 1st division. Furthermore, we verified that the higher the competition level, the lower were the values of BMI and girths measures. In the diameter measures, we observed very close values in all groups without a structural pattern in the results found.

The morphological variables that maximally distinguish the groups of gymnasts by competition levels were %BF and lower limb length. A total of 59.8% of gymnasts were well reclassified in their original groups. Furthermore, %BF was the main morphological predictor of performance in competition, explaining alone 15.6% of competition success.

Acknowledgements

The authors would like to thank the Portuguese Federation of Gymnastics, the gymnasts and their coaches who made this study possible.

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MORFOLOŠKE ZNAČAJKE PORTUGALSKIH RITMIČKIH GIMNASTIČARKI NA RAZLIČITIM RAZINAMA NATJECANJA

S A Ž E T A K

Cilj ove studije bio je: (1) odrediti i usporediti morfološke karakteristike i obilježja treninga u portugalskih ritmičkih gimnastičarki raznih natjecateljskih razina; (2) istražiti morfološke varijable s većom diskriminacijskom moći između skupina; (3) odrediti morfološke varijable koje bolje objašnjavaju uspjeh na natjecanju. Uzorak (n = 164) se sastojao od gimnastičarki na tri natjecateljske razine (osnovna, srednja i napredna). Izmjereno je 19 antropometrijskih varijabli i 2 mjere sastava tijela. Somatotip je definiran Health-Carterovom metodom. Podaci o vježbanju prikupljeni su intervjuiranjem. Za statističke analize korišteni su Kruskal-Wallisov test, linearna regresija i diskriminatorna funkcija. Portugalske gimnastičarke (13,5±2,0 godine) imale su 43,7±9,3 kg tjelesne mase, 152,6±8,9 cm visine, 18,5±2,4 kg/m^2 BMI, 17,5±4,1% tjelesne masti, endomorfni ektomorfni somatotip i 16,9±7,5 sati / tjedan volumena treninga. Elitne gimnastičarke razlikovale su se od ostalih skupina po tome što su imale niže vrijednosti kožnih nabora i tjelesne masnoće te veću učestalost vježbanja i veći broj godina vježbanja. Gimnastičarke iz napredne i srednje grupe pokazale su višu ektomorfnu i nižu endomorfnu komponentu od onih na osnovnoj razini. S obzirom na morfološke značajke i način treninga gimnastičarke iz elitne, napredne grupe najbliže su međunarodnim standardima, nakon čega slijede srednja i osnovna skupina. Varijable koje bolje razlikuju gimnastičarke prema razinama natjecanja bile su tjelesna masnoća i dužina donjih ekstremiteta. Nadalje, tjelesna masnoća pokazala se kao glavni morfološki prediktor uspješnosti u natjecanju.